Subterranean Biology 17: 121–132 (2016)
doi: 10.3897/subtbiol.17.7703
http://subtbiol.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Subterranean Biology
Published by The International Society for Subterranean Biology

Mexistenasellus floridensis sp. n., the first stenasellid isopod discovered from the Floridan aquifer (Crustacea, Isopoda, Asellota)

Julian J. Lewis[1], Thomas R. Sawicki[2]

1 *Lewis & Associates, Biological Consulting LLC, 17903 State Road 60, Borden, IN 47106 USA*
2 *Department of Biological Sciences, Florida A & M University, Tallahassee, FL 32307 USA*

Corresponding author: *Thomas R. Sawicki* (thomas.sawicki@famu.edu)

Academic editor: *O. Moldovan* | Received 5 January 2016 | Accepted 8 February 2016 | Published 1 April 2016

http://zoobank.org/B3F7DFEB-B119-4A72-848A-5924BD337CEE

Citation: Lewis JJ, Sawicki TR (2016) *Mexistenasellus floridensis* sp. n., the first stenasellid isopod discovered from the Floridan aquifer (Crustacea, Isopoda, Asellota). Subterranean Biology 17: 121–132. doi: 10.3897/subtbiol.17.7703

Abstract

Mexistenasellus floridensis sp. n. is described from Hole in Wall Cave, Jackson County, Florida. The discovery of this unique isopod nearly doubles the range of the Family Stenasellidae in North America, which was previously known from Oaxaca, Mexico to southern Texas, USA. This is the first stenasellid reported swimming in the water column of a cave, a curious finding for an isopod that belongs to a group that is generally more adapted to inhabiting interstitial spaces. *Mexistenasellus floridensis* occurs syntopically with the subterranean asellid *Caecidotea putea*. Both species have been observed swimming in the water column, although neither has apparent anatomical adaptations for swimming as compared to the natatory pereopods of *Remasellus parvus*, an asellid that occurs in caves in Alachua, Madison and Wakulla counties, Florida.

Keywords

Isopoda, Stenasellidae, *Mexistenasellus floridensis*, *Remasellus*, *Caecidotea*, Florida, cave

Copyright *Julian J. Lewis, Thomas R. Sawicki.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

The northern edge of the range of stenasellid isopods in North America was previously the Balcones Fault Zone in southcentral Texas, with the eight known species distributed from approximately 30° north latitude in Texas southward along eastern Mexico to Oaxaca at about 17° (Bowman 1982). The extraordinary discovery of a stenasellid in Florida nearly doubles the Nearctic range of the family (Figure 1), which is otherwise known from across the Palaearctic (Magniez 1999). The zoogeographic implications of this discovery are immense as there now is an area stretching over a thousand kilometers between Texas and Florida where other stenasellids might be discovered, particularly given the penchant of these isopods for inhabiting the interstices of unconsolidated sediments. Needless to say, this also opens the door to the possibility of new discoveries in Florida, where the karst is replete with large water-filled cave systems.

The history of the discovery of stenasellids in the Nearctic is relatively brief. The first species described from the New World was *Mexistenasellus coahuila* Cole & Minckley (1972) discovered along with other crustaceans in the remarkable Cuatro Ciénegas basin of northern Mexico (Cole 1984). Magniez (1972) described *M. wilkensi* and *M. parzefalli* from Cueva del Huisache, San Luis Potosi, the latter from a single female specimen. Males of *M. parzefalli* were subsequently collected and described (Magniez 1973). Argano (1974) described *M. magniezi* from Veracruz. A second genus of Nearctic stenasellid, *Etlastenasellus*, was erected by Argano (1977) to receive the new species *E. mixtecus* from Oaxaca. Bowman (1982) described a second species in this genus, *E. confinis*, from Cueva del Guayabo, in Oaxaca, as well as *Mexistenasellus colei* from Cueva de Infiernillo, Tamaulipas, and *M. nulemex* from a mine below Cueva de la Boca, in Nuevo León. By 1982 eight Nearctic species of stenasellid isopods, divided among the two genera, were known. *Mexistenasellus floridensis* is the first new Nearctic stenasellid to be described since that time.

Bowman (1982) alluded to the presence of stenasellids in the United States in reference to an unidentified collection in Texas. This was confirmed by Bowman (1992) as a range extension of *Mexistenasellus coahuila* in springs and artesian wells in Bexar County and a hyporheic habitat in Medina County, Texas (Figure 1). Little karst and few caves are present in the states between the Texas and Florida populations. However, evidence of the presence of groundwater habitats in the intervening area exist in records of the subterranean asellid *Caecidotea paurotrigonus* from a drain tile in Mississippi (Fleming 1972), a hole dug in soil in Louisiana (Lewis 2000), and the possibly conspecific *Caecidotea dauphina* from a drain tile outlet on Dauphin Island, Alabama (Modlin 1986). With the description of *Caecidotea phreatica* from saturated soil habits in coastal Virginia, Lewis and Holsinger (1985) discussed other species of *Caecidotea* occurring in similar habitats in the Gulf Coastal Plain physiographic province. These included *C. hobbsi* from crayfish burrows in Florida (Steeves 1966) and *C. beattyi* from drain tiles in southern Illinois (Lewis and Bowman 1981). There clearly remains a large geographic area where stenasellids might occur in the southeastern US.

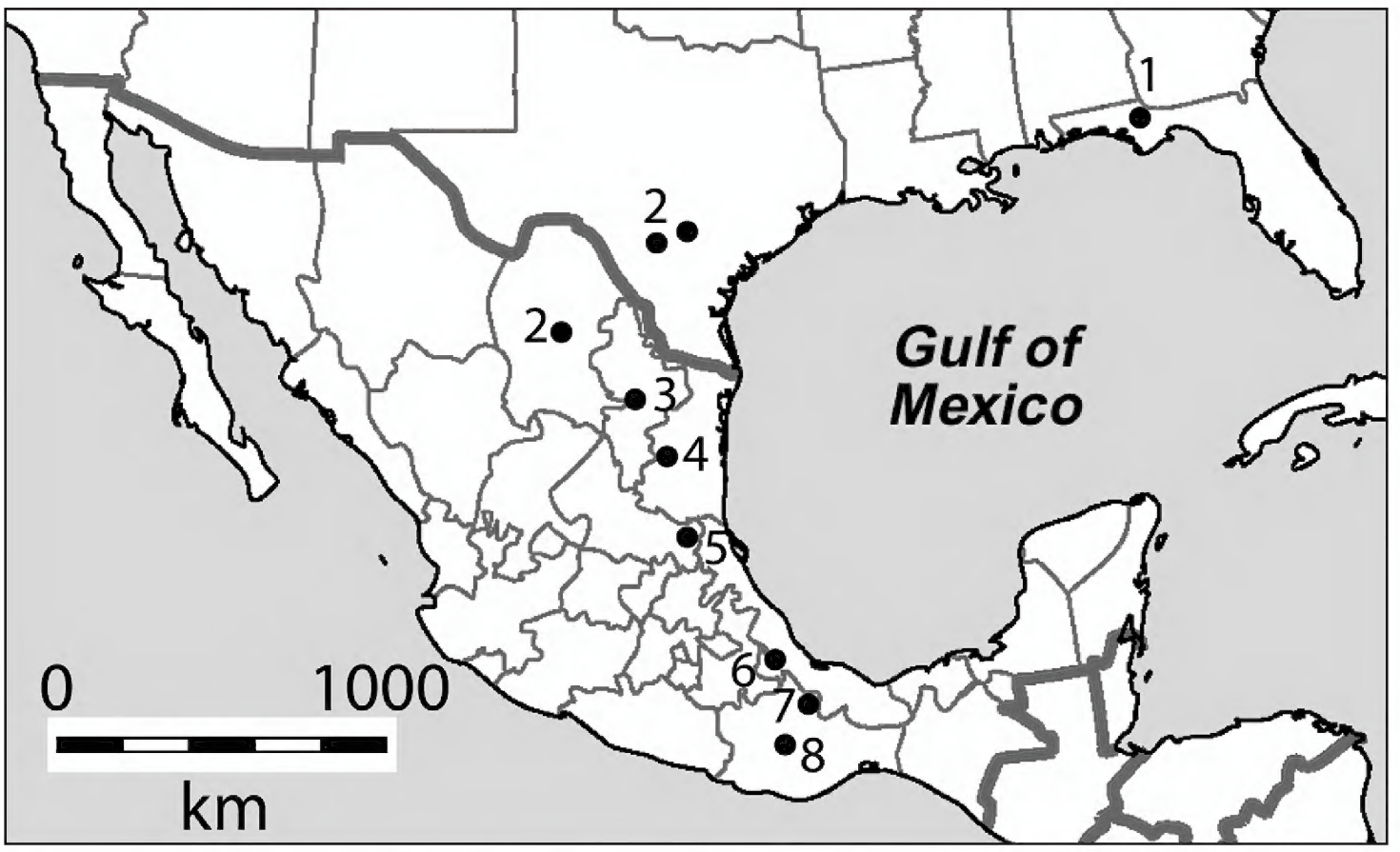

Figure 1. Distribution of Stenasellid isopods in the Nearctic Region: **1** *M. floridensis* **2** *M. coahuila* **3** *M. nulemex* **4** *M. colei* **5** *M.parzefalli* and *M. wilkensi* **6** *M. magniezi* **7** *Etlastenasellus confinis* **8** *E. mixtecus*.

Systematic part

Family Stenasellidae Dudich, 1924
***Mexistenasellus* Cole & Minckley, 1972**

***Mexistenasellus floridensis* sp. n.**
http://zoobank.org/F45C7937-CE7A-45E8-A295-AA1244B4CCBE
Figures 1–5

Material examined. USA: FLORIDA: Jackson County, Hole in Wall Cave, approximately 7 km east of Marianna (N30.78334 W85.15671), male holotype, 3 male and 2 female paratypes, collected 19 October 2013, Thomas R. Sawicki and Michael Stine; same locality, 3 male and 1 female paratypes, 2–3 January 2009, Thomas R. Sawicki. The specimens are deposited in the collection of the US National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Description. Eyeless, unpigmented, longest male approximately 9.0 mm, female 9.4 mm. Body slender, linear, about 4.3× as long as wide. Head about 1.4× as wide as long, rostrum and lateral incisions absent. Coxae not visible in dorsal view. Body becoming more dorsally spinose on pereonites 6–7 and pleon. Pleotelson about 1.65× as long as wide, caudomedial lobe moderately produced, broadly rounded.

Antenna 1 of 20 articles, distal 6 articles each with one esthete, then alternate articles with one esthete (8 esthetes total). Antenna 2 broken or detached in most specimens, flagellum 57–58 merous, esthetes absent. Mandibles with 4-cuspate incisors

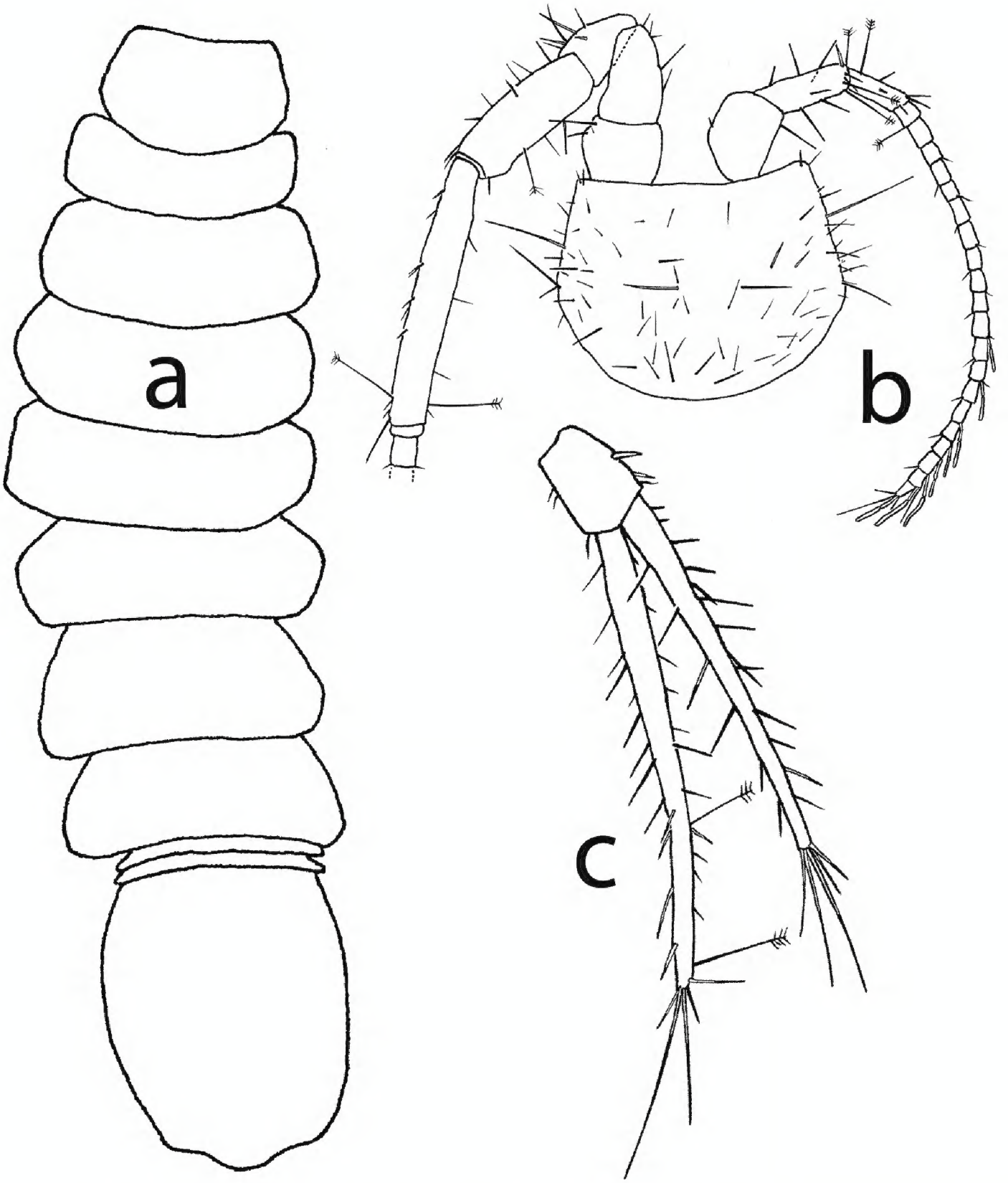

Figure 2. *Mexistenasellus floridensis* sp. n., male: **a** habitus **b** head, antenna 1, antenna 2 peduncle **c** uropod.

and lacinia; spine row with 5 spines on left, 4 spines on right, both with simple stout spines adjacent to incisors that resemble the cusps of the incisors and spines distad from incisors with complex plumosity; left molar with row of 15 plumose setae, right molar with row of 12 plumose setae. Mandibular palp 3-merous, with plumose setae on distal articles. Maxilla 1, inner lobe with 4 apical stout plumose spines; outer lobe with 12 dentate apical spines. Maxilliped without retinaculae.

Pereopods with sexual dimorphism not apparent. Pereopod 1, dactyl with elongate spine resembling accessory claw, 0.8× length of claw; propodus about 2.1× as long as

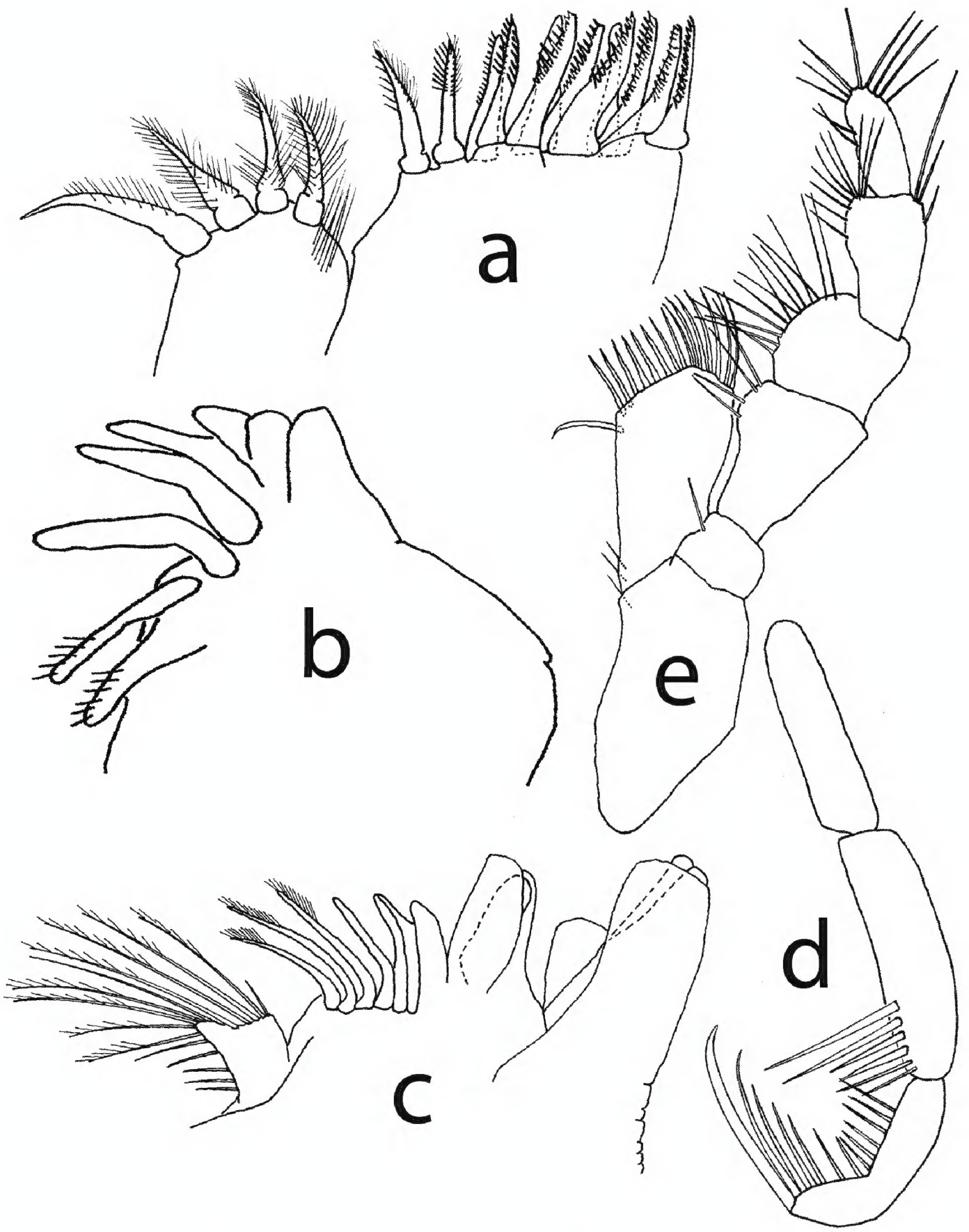

Figure 3. *Mexistenasellus floridensis* sp. n., mouthparts: **a** maxilla 1 **b** mandible, right, incisors **c** mandible, left, incisors and lacinia **d** mandibular palp **e** maxilliped.

wide, palmar margin with 4–6 robust plumose spines; carpus with 3–4 spines continuing from propodus. Pereopods 2–7 increasing in length, pereopod 7 longest; dactyls with prominent elongate claw-like spine parallel to claw.

Male pleopod 1, protopod with retinaculae absent; exopod oval with 5 elongate disto-lateral setae. Female pleopod 2 triangular, about 2.1× as long as wide, with 3 setae

inside mesial margin, 1 distal seta and 1 lateral seta at mid-point. Male pleopod 2, protopod elongate, about 1.7× as long as wide; exopod, proximal article sub-equal in length to distal article, setae absent, distal article broadly rounded apically, with 5 lateral setae; endopod, setation absent, distal article about 2× length of proximal article, bent at approximately 60 degree angle to proximal article, tip bi-lobed, separated by endopodial groove terminating in sub-conical stylet (cannula). Pleopod 3, exopod with transverse suture, distal area slightly longer than proximal, with submarginal spines in row along mesial margin, spines and setae along distal and lateral margins; endopod about 0.6× length of exopod, bifurcated distally. Pleopod 4, exopod with oblique suture, about 2.5× as long as wide, area distal to suture about 0.67× length of proximal area, with about 32 marginal setae; endopod about 0.6× length of exopod, bifurcated distally. Pleopod 5, exopod with oblique suture, setae absent, about 2.5× as long as wide, area distal to suture about 0.3× length of proximal area; endopod sub-equal in length to exopod, bifurcated distally.

Uropods about 2.4mm in length, equal to pleotelson; rami slender, linear, endopod 5× length of protopod, 1.25× length of exopod.

Etymology. Named for the state of Florida, in recognition of the first stenasellid discovered in the United States east of the Mississippi. Suggested vernacular name is the Florida cave isopod.

Relationships. Magniez (1981) believed that the North American stenasellidae would prove to be multi-generic, although the paucity of collections has so far supported the partitioning of the New World taxa into only two genera (Magniez 1999; 2008). Within the genus *Mexistenasellus*, *M. floridensis* seems to most closely resemble *M. coahuila* and *M. colei*. The male pleopod 2 endopodite of all three species is an elongate, sub-rectangular structure terminating in a short stylet that is presumably the sperm transfer cannula, surrounded by the rounded terminal lobes of the endopodial groove. The exopod of each is divided by a suture into two sub-equal parts, with sparse setation along the distal margin. The first maxilla of all three species also share an inner lobe with 4 setae and outer lobe with 12 apical spines.

Nearctic *Mexistenasellus* species can be tentatively identified by their ranges (Fig. 1). From a morphological standpoint, *Mexistenasellus floridensis* is separated from the most similar species (*M. colei*, *M. coahuila*) by the structures of the male second pleopod, namely the more slender, elongate endopodite and the presence of five setae along the margin of the exopod, as compared to one seta in the other species. Other unique morphological aspects of *M. floridensis* include the absence of retinaculae on the maxilliped and the distally bifurcate endopods of pleopods 3–5.

When Cole and Minckley (1972) described the first stenasellid discovered in the Nearctic Region they noted the morphological resemblance between *Mexistenasellus coahuila* in northeastern Mexico and *Parastenasellus* from northern Africa. Magniez (1981) concurred with Cole and Minckleys' observation, and further compared the morphology of *M. coahuila* with the African stenasellid genera *Parastenasellus*, *Magniezia* and *Metastenasellus*. The male second pleopods of all of these genera are similar, excluding *Metastenasellus*, which possesses a spiraled-appearing endopodite that is quite dissimilar.

The hypothesis of Magniez entails colonization of groundwater by the stenasellid ancestors prior to the separation of Africa and South America during the early

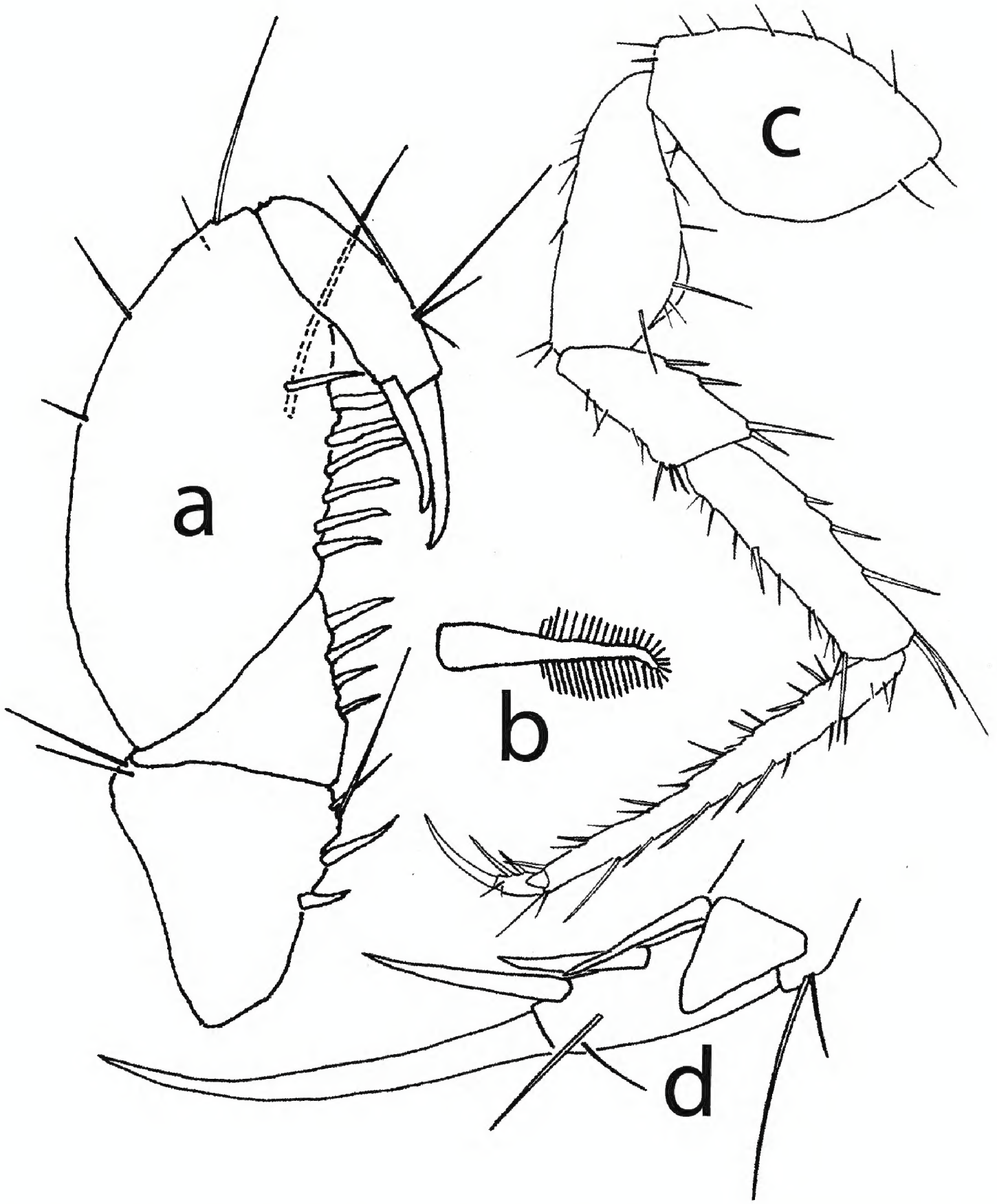

Figure 4. *Mexistenasellus floridensis* sp. n., pereopods: **a** pereopod 1 distal articles, female **b** spine, pereopod 1, palmar margin of proprodus **c** pereopod 7, male **d** same, dactyl.

Cretaceous (140–150 million years before present). This idea requires the presence of stenasellids in South America that remain to be discovered, and subsequent dispersal to North America during the Cenozoic. Magniez acknowledged the flaw in the hypothesis presented by the fact that the North and South American continents were separated during the majority of the Cenozoic. This problem is avoided by pushing back the invasion of freshwater habitats by stenasellids even further, to a time prior to the rifting of Pangea during the Jurassic (about 175 million years b.p.).

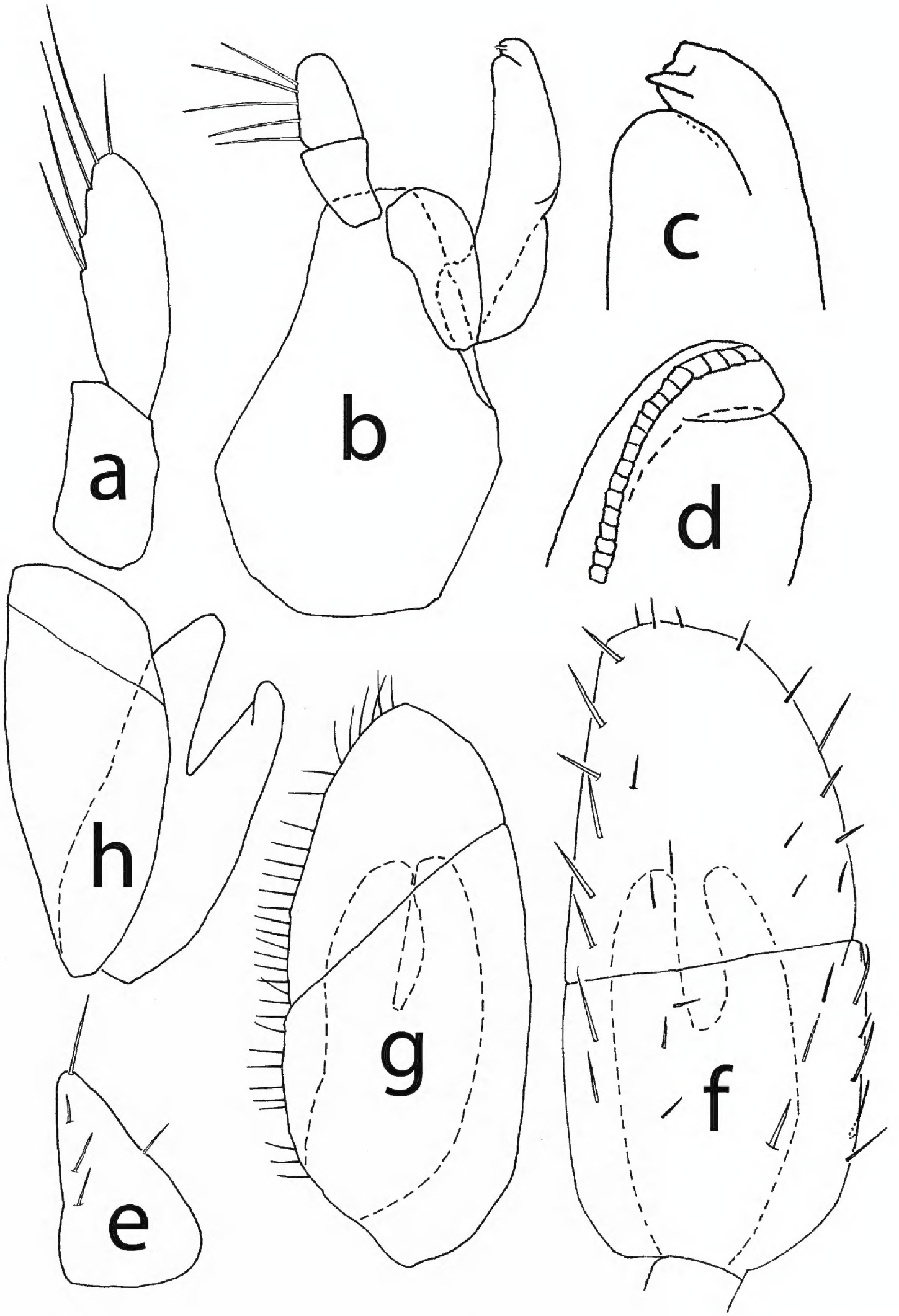

Figure 5. *Mexistenasellus floridensis* sp. n. pleopods, male except 4e: **a** pleopod 1 **b** pleopod 2 **c** same, tip of endopodite, anterior **d** same, posterior **e** pleopod 2 **f** pleopod 3 **g** pleopod 4 **h** pleopod 5.

The molecular genetic analysis of stenasellids by Morvan et al. (2013) supports the hypothesis that stenaselllids were present on Pangaea. Their data indicates that *Mexistenasellus* and *Magniezia* are sister groups and form a group separate from *Stenasellus*, with divergence possibly dating to the late Paleozoic. If one assumes that the African precursors were present prior to the breakup of Pangea, the theoretical presence of stenasellids in South America is no longer necessary. On the other hand, the molecular data do not support the argument of Bowman (1982) that supposed the invasion of groundwater in Mexico by the marine ancestors of *Mexistenasellus* as the shallow marine embayment regressed during the early Cenozoic.

Ecology. The Hole in Wall Cave is a water-filled cave system that is a popular dive site located in Merritt's Mill Pond, east of Mariana, Florida. The cave was mapped by Exley (1978) with the current surveyed length of approximately 8.5 km and maximum depth of 42.3 m. The isopods were collected as they swam, mid-water, at an average depth of approximately 24 m.

This observation of the isopods swimming is curious since the pereopods of *Mexistenasellus floridensis* do not exhibit the dense rows of setae present on the legs of *Remasellus parvus* that appear to be natatory adaptations. Regardless of how ill-prepared the isopods were for swimming that was precisely what they appeared to be doing each time specimens were collected. The asellid *Caecidotea putea* Lewis (2009) was also present in the water column with *M. floridensis*. This isopod seems no more morphologically adapted for swimming than the stenasellid.

On 17 July 2015 and 31 July 2015, dives were conducted in Hole in the Wall Cave to conduct careful behavioral observations of the isopods as well as to collect physicochemical data from the cave and surface pond. During these dives isopods were observed crawling on the floor, walls, and ceiling of the cave, as well as swimming in the water column. The swimming behavior observed in these animals may be in response to physical disturbance. This hypothesis is based on the fact that isopod swimming behavior was observed more frequently by the second diver than the lead diver as the team swam through the cave. Both *Mexistenasellus floridensis* and *Caecidotea putea* exhibited a fluid, graceful swimming motion. This fact at least suggests that although fin kicks and bubbles exhaled from SCUBA equipment may have induced their movement, it is not an unfamiliar, artificial behavior. It is easier to visually spot the isopods as they swim in the water column, where their unpigmented bodies are set against the dark cave background, than against the white limestone walls and ceilings or the silt-covered bottom. Due to this fact divers were focused on collecting animals that were swimming in the water column, and therefore likely missed many isopods that may have been crawling on surfaces within the cave. In total, these facts may explain why animals, seemingly poorly adapted for swimming, were collected solely from the mid-water column.

This swimming behavior may be an adaptive flight response to escape predation from the crayfish *Cambarus cryptodytes*, the Georgia cave salamander *Eurycea wallacei* or the trogloxene yellow bullhead catfish *Ameiurus natalis*. Other members of the community, a subset of the Florida subterranean fauna discussed by Franz et al. (1994),

Table 1. Physicochemical data correlated with depth. The 2 m reading was outside of the cave in the open water of Merritt's Mill Pond. The deepest sections of the cave correlated with the lowest temperature, pH, and DO, and highest specific conductivity.

Depth m	Temperature °C	pH	Dissolved Oxygen		Conductivity µS/cm
			mg/l	% Saturation	
2,21	20,58	7,37	5,82	64,7	315
19.57–29.5	20.08–20.22	7.36–7.39	5.22–5.28	57.6–58.3	318–327
30.0–31.53	18.73–19.97	7.31–7.32	3.01–4.88	32.2–53.6	333–359

were the stygophilic amphipod *Crangonyx floridanus* and other (probably undescribed) stygobitic amphipods.

During the 31 July 2015 dive, physicochemical data was taken using a Hydrolab HL4 sonde. Readings of depth, temperature, pH, conductivity, and dissolved oxygen (DO) were recorded every 20 seconds continuously during the dive. Dive bottom time (time spent swimming through cave passages and not entering and exiting the cave) was 51 minutes, and 155 separate readings were taken with depth varying between 19.57 and 31.53 meters. Readings were also taken in the open water of Merritt's Mill Pond. For each parameter measured, the shallowest regions of the cave most closely approximated the pond water; however, temperature, pH, and DO progressively decreased with depth and specific conductivity increased with depth (Table 1). The lowest temperature, pH and DO, and highest conductivity were measured below 31 meters. The cold, low DO, high conductivity water entered the main cave passage from deep side tunnels at approximately 600 meters from the cave entrance. One of us (TRS) has explored these cave passages for the past six years and has noted seasonal variation in cave water temperature at depths between 19 and 30 meters. In total, these data suggest that the cold water entering the primary passage comes from deep water sources, less influenced by seasonal variation. While no isopods were observed in this colder water, stygobitic amphipods were collected.

Concerning reproduction, a 7.4 mm female *M. floridensis* was ovigerous with a brood pouch containing eggs approximately 0.5 mm in diameter. Another post-ovigerous female released 32 juveniles about 1.4 mm in length.

Acknowledgements

The senior author gratefully acknowledges conversations and suggestions regarding stenasellids with his friend and colleague, the late Dr. Guy Magniez. The authors would like to thank Dr. Michael Stine for sharing his time and cave diving expertise in assisting with the collection of specimens for this project. We would also like to thank the staff at Cave Adventurers for their professionalism and sharing their local knowledge. Funding for this project was provided by the American Public University System Faculty Research Grant.

References

Argano R (1974) *Mexistenasellus magniezi* n. sp., a blind aquatic isopod from Veracruz, Mexico (Crustacea). Accademia Nazionale dei Lincei 171: 97–103.

Argano R (1977) Asellota del Messico meridionale e Guatemala (Crustacea, Isopoda). Accademia Nazionale dei Lincei 171: 101–124.

Botosaneau L, Iliffe TM (2002) Stygobitic isopod crustaceans, already described or new, from Bermuda, the Bahamas, and Mexico. Biologie 72: 101–111.

Bowman TE (1982) Three new stenasellid isopods from Mexico (Crustacea: Asellota). Association for Mexican Cave Studies Bulletin 8 and Texas Memorial Museum Bulletin 28: 25–38.

Bowman TE (1992) Two subterranean aquatic isopod crustaceans new to Texas: *Mexistenasellus coahuila* (Cole and Minckley, 1972) (Asellota: Stenasellidae) and *Speocirolana hardeni*, new species (Flabellifera: Cirolanidae). Texas Memorial Museum, Speleological Monographs 3: 23–30.

Cole GA (1984) Crustacea from the Bolsón on Cuatro Ciénegas, Coahuila, Mexico. Journal of the Arizona-Nevada Academy of Science 19: 3–12.

Cole GA, Minckley WL (1972) Stenasellid isopod crustaceans in the Western Hemisphere – a new genus and species from Mexico – with a review of other North American freshwater isopod genera. Proceedings of the Biological Society of Washington 84: 313–326.

Exley S (1978) Map of Hole in the Wall, Jackson County, Florida. 1 sheet.

Fleming LE (1972) Four new species of troglobitic asellids (Crustacea: Isopoda) from the United States. Proceedings of the Biological Society of Washington 84(57): 489–500.

Franz R, Bauer J, Morris T (1994) Review of Biologically Significant Caves and their Faunas in Florida and South Georgia. Brimleyana 20: 1–109.

Lewis JJ (2000) *Caecidotea cumberlandensis*, a new species of troglobitic isopod from Virginia, with new records of other subterranean *Caecidotea* (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington 113(2): 458–464.

Lewis JJ (2009) On the identity of *Caecidotea nickajackensis* (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington 122(2): 215–224. doi: 10.2988/08-47.1

Lewis JJ, Bowman TE (1981) The subterranean asellids (*Caecidotea*) of Illinois (Crustacea: Isopoda: Asellidae). Smithsonian Contributions to Zoology 335: 1–66. doi: 10.5479/si.00810282.335

Lewis JJ, Holsinger JR (1985) *Caecidotea phreatica*, a new phreatobitic isopod crustacean (Asellidae) from southeastern Virginia. Proceedings of the Biological Society of Washington 98(4): 1004–1011.

Magniez G (1972) Deux Stenasellidae cavernicolous nouveaux de l'Amerique centrale: *Mexistenasellus parzefalli* n. sp. et *Mexistenasellus wilkensi* n. sp. (Crustacea, Isopoda, Asellota). International Journal of Speology 4: 19–31. doi: 10.5038/1827-806X.4.1.3

Magniez G (1973) Description du mâle de *Mexistenasellus parzefalli* (Crustacea Isopoda Asellota cavernicole du Mexique) et observations sur cette espèce. International Journal of Speleology 5: 163–170. doi: 10.5038/1827-806X.5.2.8

Magniez G (1981) Biogeographical and paleogeographical problems in stenasellids (Crustacea Isopoda Asellota of underground waters). International Journal of Speleology 11: 71–81. doi: 10.5038/1827-806X.11.1.8

Magniez G (1999) A review of the family Stenasellidae (Isopoda, Asellota, Aselloidea) of underground waters. Crustaceana 72(8): 837–848. doi: 10.1163/156854099503988

Magniez G (2008) From 1896 to 2008, a sight of the stygobitic Family Stenasellidae (Crustacea, Isopoda, Asellota). In: Symposium abstracts of the 19th International Symposium of Subterranean Biology, Fremantle (Australia), 21–26 September 2008, Snap Printers, Belmont (Australia), 60 pp.

Modlin RF (1986) *Caecidotea dauphina*, a new subterranean isopod from a barrier island in the southern Gulf of Mexico (Crustacea: Isopoda: Asellidae). Proceedings of the Biological Society of Washington 99(2): 316–322.

Morvan C, Malard F, Paradis E, Lefébure T, Konecny-Dupré L, Douady CJ (2013) Timetree of Aselloidea reveals species diversification dynamics in groundwater. Systematic Biology 62(4): 512–522. doi: 10.1093/sysbio/syt015

Steeves III HR (1966) Evolutionary aspects of the troglobitic asellids of the United States: the Hobbsi, Stygius and Cannulus groups. American Midland Naturalist 75(2): 392–403. doi: 10.2307/2423400